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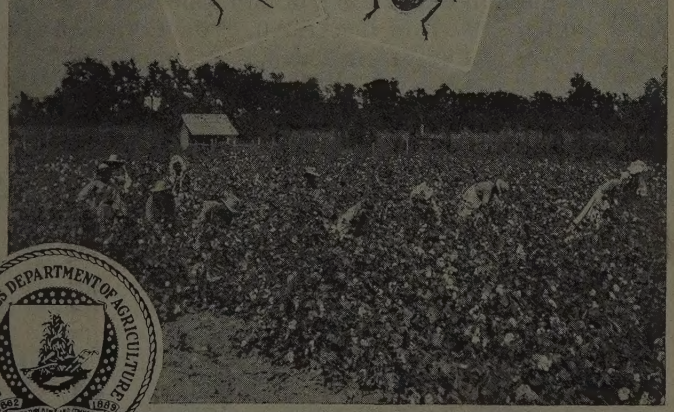
FARMERS' BULLETIN No. 1688

INSECT ENEMIES OF THE COTTON PLANT



1932

THE COTTON PLANT is unusually attractive to insects and probably no other cultivated crop has so large a list of insect enemies. Among these are some of the most destructive pests of agriculture.

Rotation of crops is of assistance in controlling many cotton pests. Weeds should not be allowed to grow near the cotton, for many pests come to the cotton from other crops or from weeds around the fields. Thorough fall plowing, winter cover crops, early spring preparation, and repeated cultivation during the season are important measures of insect control. An early crop is necessary.

The cotton plants should be turned under in the fall—if possible, before frost.

This bulletin describes many cotton insects and their work, and gives suggestions for their control. A system of control effective against most of the insects referred to is given in summary form at the close of the bulletin.

This bulletin is a revision of and supersedes Farmers' Bulletin 890, How Insects Affect the Cotton Plant and Means of Combating Them.

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INSECT ENEMIES OF THE COTTON PLANT

By J. W. Folsom, *Senior Entomologist, Division of Cotton Insects, Bureau of Entomology*

J.T.R.

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TO CARRY ON successfully the inevitable and incessant war against insect enemies of his crop and his income, the cotton grower must be able to recognize each of the more injurious cotton pests and its work when he sees them and must know how each pest can be controlled.

Although the cotton plant is highly attractive to insects and has a long list of insect enemies, not all of the insects found in the cotton field are there as a menace to the cotton plant. Some of them feed on the pests themselves and others exist without damaging the crop.

The worst insect enemies of the cotton crop as a whole—those that appear most often and do the most damage when they do appear—constitute the group which will be discussed first in this publication.

INSECT COTTON PESTS OF GREATEST IMPORTANCE

THE BOLL WEEVIL

In the United States the boll weevil (*Anthonomus grandis* Boh.) has in some years caused a loss in the cotton crop of more than $200,000,000. The weevil now covers almost the entire main Cotton Belt, where the necessity of combating it has revolutionized the methods of cotton production.

The insect (fig. 1) winters as an adult in sheltered places. The weevils that survive the winter emerge from hibernation over a long period, usually from about March 1 to about July 1, and attack squares and young bolls, although preferring the former.

In these they make punctures for feeding or for egg laying. Punctured squares flare open conspicuously (fig. 2) and usually fall to the ground in a few days. A large number of squares are shed naturally, of course, and additional shedding may be caused by weather conditions or careless cultivation. Immature weevils die quickly in the shed bolls; in fact, heat and dryness are important natural controls of the boll weevil. A puncture made by a weevil in feeding remains open, but an egg puncture is sealed with a wart-like plug. The egg hatches in about 3 days into a stout white larva, with a head but without legs. (Fig. 3, left.) This larva feeds inside a square or boll, becomes full grown in from 7 to 12 days, and passes from 3 to 5 days as a pupa (fig. 3, right), from which the beetle emerges. Small bolls drop if severely punctured. Larger bolls in which weevils are developing, may decay and dry up without opening, or may open and show one

FIGURE 1.—Boll weevil adults: *a*, Viewed from above; *b*, from the side. About five times natural size. (Hunter and Coad)

FIGURE 2.—Weevil injury to cotton square. The square to the left has been punctured and shows typical "flaring" bracts, whereas the one to the right is uninjured. (Hunter and Coad)

or more locks ruined by weevil attack. As the period from egg to adult is only from two to three weeks in length, there may be several generations of the weevil in a single season.

It is possible to control the boll weevil effectively and profitably.[1] The most approved method of direct control is to dust cotton plants with calcium arsenate, beginning as soon as 10 per cent of the squares have been punctured.[2] The poison should be applied, at the rate of from 4 to 6 pounds per acre, when the air is reasonably calm and the plants are moist. Three or more applications at 5-day intervals may be necessary to reduce the infestation to less than 10 per cent. Additional applications may become necessary later on. If a heavy rain falls within one day after dusting, repeat the application as soon as possible.

If overwintered weevils are unusually abundant in the field in early spring, an application of calcium arsenate dust before the plants begin to put on squares is advisable. Use from 2 to 3 pounds per acre. For this dust application shakers, bags, or the like may be used, or any type of dusting machine recommended for later applications, provided the nozzles are lowered sufficiently for the dust to reach the small plants. Or, a molasses mixture consisting of 1 pound calcium arsenate, 1 gallon of water, and 1 gallon of molasses, thoroughly mixed together, may be used. It is applied to the plants at the rate of 1 gallon per acre by means of a homemade rag mop, when the cotton begins to square.

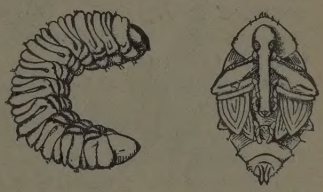

FIGURE 3.—Immature stages of boll weevil: Larva at left, pupa at right. About five times natural size. (Hunter and Coad)

When using dusting machinery employ only that which is specially constructed for cotton dusting.

Airplane dusting has many advantages, especially on large, level, open areas, and usually costs no more than dusting with ground machines.

In fighting the boll weevil it is most important to get as early a crop of cotton as possible—in other words, to get the crop beyond the square stage before the weevils have become sufficiently numerous to prevent the bolls from setting. This involves not only the selection of an early-maturing variety of cotton adapted to the locality, but also the plowing and working of the soil to prepare an early seed bed, planting as early as is safe, and stimulating plant growth by proper cultivation, with fertilization if necessary. The boll weevil places a premium on good farming.

Where conditions permit, after the cotton is picked the plants should be destroyed before the first killing frost by plowing them under or burning them. This is important. Cleaning up and burning dead weeds and other trash in winter reduces the number of hibernating weevils.[3]

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[1] U. S. Dept. Agr. Leaflet 37, Poisoning the Cotton Boll Weevil.

[2] To determine when 10 per cent of the squares are infested, pick 100 squares from each of the four corners and from the center of the field—500 in all. If 50 of these squares are infested, it is time to start dusting.

[3] See Farmers' Bulletin 1329, The Boll Weevil Problem, and Farmers' Bulletin 501, Cotton Improvement Under Weevil Conditions.

THE THURBERIA WEEVIL

Although extremes of heat and dryness are fatal to the boll weevil, the variety known as the Thurberia weevil (*Anthonomus grandis* Boh., var. *thurberiae* Pierce) thrives in arid regions. This variety is a native of mountain ranges in southeastern Arizona, where it feeds on a species of wild cotton (Thurberia) which grows in the beds of canyons and along small washes. It breeds and passes the winter in bolls of this plant, almost always as a beetle. Infested bolls do not open and drop the seeds but remain almost closed, and many such bolls fall to the ground and are carried down to the plains by floods. After sufficient rains the bolls rot and release the beetles, which emerge commonly in July or August and may spread by flight. This weevil is known to occur in parts of five counties in Arizona. It is increasing in numbers in the cultivated sections and is now infesting some 12,000 acres of cotton, largely in the Santa Cruz Valley.

On the wild cotton the weevil has only one and a partial second generation annually, but when living on cultivated cotton it produces as many as three generations and winters in the bolls as a rule, though some beetles emerge and winter in other shelter. The numbers of such weevils may be greatly reduced by breaking down and burning old cotton stalks in the fall. This weevil in cultivated cotton may be controlled in the same way as the boll weevil.

Strict quarantine regulations are being enforced in the effort to restrict this weevil to the present infested areas. The regulations permit movement of articles likely to carry the weevil from points within the infested area to points outside only after compliance with adequate safeguards. These regulations give protection to all uninfested cotton-growing sections of the United States, either within Arizona or elsewhere.

THE COTTON LEAF WORM

Until the arrival of the boll weevil, the leaf worm (*Alabama argillacea* Hbn.) and the bollworm were our two worst cotton pests. The leaf worm is not known to survive the winter in the United States, but is a native of tropical or subtropical America. In some years the moths enter this country, usually through Texas, rarely through Florida, and multiply on cotton throughout the growing season, becoming more abundant with each generation, and spreading over the main Cotton Belt until they often reach the Northern States and even Canada.

The activity of the leaf worm varies greatly in different years, but this insect is injuriously abundant much oftener west of the Mississippi River than in the Southeastern States.

In southern Texas there may be at least seven generations of the insect annually. Early broods of worms, by destroying the leaves of the cotton plant, may prevent the bolls from maturing. Late broods not only "rag" the leaves (fig. 4) but may strip every plant in a field of its leaves and squares, gnaw into bolls and bark, and then crawl away in search of more cotton—their only food plant. The brown, defoliated field looks as if it had been swept by fire. The

defoliation causes a premature opening of the bolls that results in a lower grade of cotton, and the lint is stained and further damaged by the excrement of the worms.

FIGURE 4.—Stages and work of the cotton leaf worm. (Hunter)

The caterpillars vary greatly in coloration, but each segment of the abdomen as seen from above shows four round black dots in the form of a square.

For the first few days after hatching, the worms feed on the undersides of leaves, not eating clear through a leaf, but leaving the upper skin. The spots thus made turn brown and are early indications that the worms are present. Later the worms move to the tops of plants to feed, and then are easily poisoned with arsenicals.

Calcium arsenate at the rate of 5 pounds or more per acre, applied in the same manner as for boll weevil control, is most effective when the worms are young and the infestation is beginning. With a heavy infestation of large worms the killing may be somewhat slow and a heavier dosage, or a mixture of calcium arsenate and Paris green, containing from 15 to 20 per cent of the latter, may be used. Paris green may be used also as in the following mixture: 1 part of Paris green, 1 part of flour for a sticker, and about 5 parts of lime to prevent burning. From 12 to 14 pounds of this mixture should be applied per acre. In emergencies other stomach poisons can be used, but they are usually not so satisfactory as those just named.

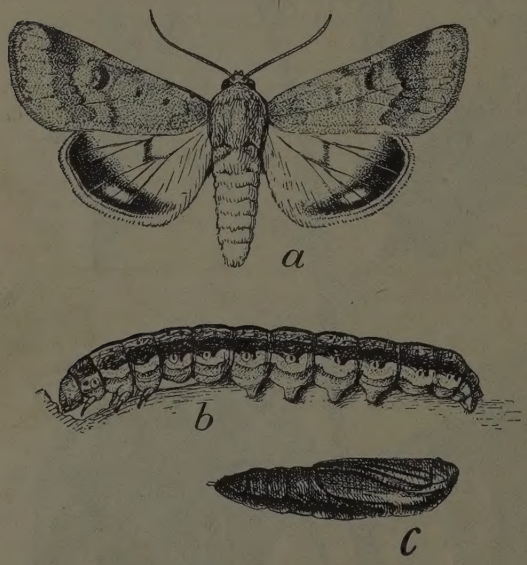

FIGURE 5.—Bollworm: *a*, Moth or adult; *b*, larva, or worm; *c*, pupa. About natural size. (Howard)

THE BOLLWORM

The bollworm (*Heliothis obsoleta* Fab.), known also as the corn ear worm and the tomato fruit worm, feeds on some 70 plants, but is most destructive to corn, cotton, tomato, and tobacco. Though it may severely damage cotton, its occurrence in any one district is very irregular. In the South early generations feed on field corn, and when this hardens in summer the moths lay their eggs on cotton plants. The caterpillars (fig. 5, *b*) feed only slightly on foliage. They attack the flowers or bore into squares or bolls and eat out part or all of the contents, and one caterpillar may injure several of these forms. Infested squares flare open and usually drop to the ground. By far the greatest loss caused by this insect, however, is due to its attacks on the bolls. When squares or bolls are not available the insect has the bad habit of cutting off the growing tips of cotton plants.

In the Cotton Belt there are from four to six generations of the bollworm each year. The insect winters as a pupa (fig. 5, *c*) in a cell a few inches below the surface of the soil.

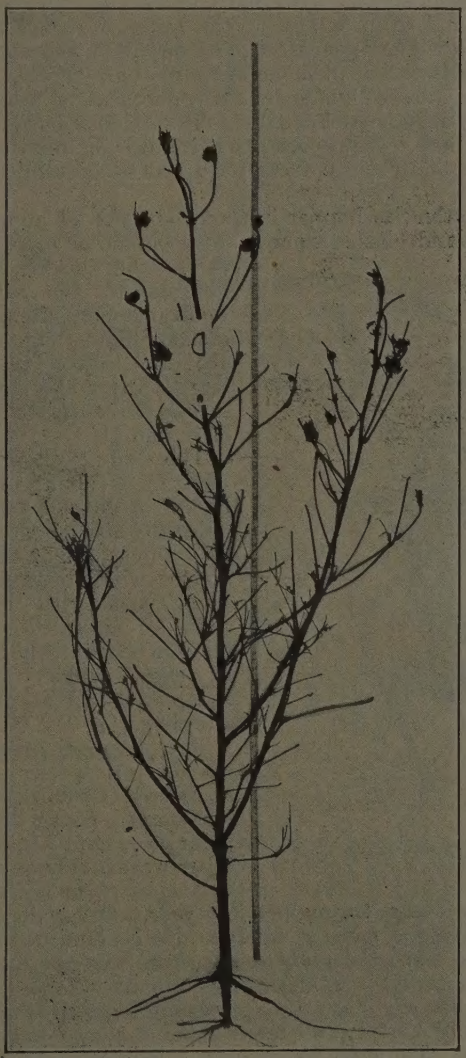

FIGURE 6.—Cotton plant deformed by the attacks of the cotton flea hopper. The leaves have been removed to show the characteristic branching due to the insect's attack

As older cotton bolls are less subject to attack than are the squares and younger bolls, efforts should be made to hasten the maturity of the crop, as in the case of the boll weevil. After picking, cotton stalks should be destroyed by plowing or by burning. Late fall or winter plowing destroys the pupae in the soil.

Dusting with calcium arsenate, as for the boll weevil, is recommended. The applications should be made from July 10 to August 20, according to latitude and other conditions.[4]

THE COTTON FLEA HOPPER

A peculiar disorder of the cotton plant, known for a third of a century, has in recent years been proved to be caused by the cotton flea hopper (*Psallus seriatus* Reut.) and a few other insects related to it. Usually the flea hopper has been the predominating species.

An alarming sign of this disorder is the failure of plants to produce blooms. This is due to the destruction of the very tiny squares by the punctures of the hopper. Punctured squares are blasted, turn brown or black,

[4] Farmers' Bulletin 1595, The Bollworm or Corn Ear Worm as a Cotton Pest.

and fall from the plant. Another characteristic of hopper damage is the abnormal growth and branching of affected plants. (Fig. 6.) Branching of such plants is erratic, with many suckers or other surplus branches present, and often a few of the lower branches are abnormally large. After the hoppers have gone the plant sometimes becomes unusually tall. Less conspicuous, but also characteristic of hopper damage, are the wounds made by the punctures on stems, branches, and leaves before buds are available. Plant cells surrounding the punctures are killed. This effect is local, however, for there is as yet no evidence that any virus from the insect is transmitted through the plant.

Associated with the cotton flea hopper in the production of hopper damage, including scars and blasted squares, may be one or more of three other insects belonging to the same family, namely, the tarnished plant bug (p. 18), the cotton plant bug (p. 18), and a third species, *Creontiades debilis* Van D.

FIGURE 7.—Adult stage of the cotton flea hopper, 20 times natural size

The adult hopper (fig. 7) is about one-eighth of an inch long, pale greenish or grayish, thickly dotted above with brownish spots, and with two pairs of characteristic black marks near the tip of each wing. The nymphs are green and wingless.

The hopper breeds on several species of goatweed (Croton), on horsemint, evening primrose, and many other weeds. The principal host plant is Croton, on which the hopper occurs throughout the year. Other plants are temporary hosts. Horsemint is a favorite food plant of the hopper in parts of Texas until the plant dries up in May or June, forcing the hoppers to migrate to cotton or other plants.

The hopper winters in the egg stage, the eggs being inserted singly under the bark of stems of Croton and many other kinds of weeds, and sometimes in cotton. The eggs hatch over a long period. At College Station, Tex., they are hatching from about February 15 to July 1, with the maximum emergence in the last week of March. At Tallulah, La., the period is from March 9 to June 1, with the peak of emergence in the last week of April. From Croton many of the hoppers go to the cotton plants. The young, or nymphs, probably are often carried by the wind.

As the life cycle of the insect, from egg to egg, takes only from two to four weeks, according to the time of year, there is an opportunity for the occurrence of from 6 to 12 generations annually, or an average of 9.

As a general practice, weeds in the vicinity of cotton fields should be destroyed. Croton or goatweed in particular should be eradicated by burning in late fall or in winter. Old cotton stalks should be destroyed, as they also may contain eggs of the hopper.

A method of control recommended at present is dusting with finely ground sulphur at the rate of 10 pounds per acre, when the air is reasonably calm. The presence of many blasted squares on the plants is an indication that dusting should begin. A second application should be made four or five days later, with such additional applications as may be necessary. Often two applications are sufficient. After the sulphur applications the disappearance of hoppers from a field is gradual, and freshly blasted squares may be found even as late as 12 days after hoppers have left the plants.

Where boll weevils as well as hoppers are prevalent, a combined application of 8 pounds of sulphur and 4 pounds of calcium arsenate per acre should be used.

Sulphur dust is highly inflammable and explosive. It should not be exposed to a flame of any kind and should not be applied to cotton with machinery operated by a gasoline engine, without extreme care.

FIGURE 8.—Cotton aphid: *a*, Winged female; *ab*, dark female, side view; *b*, young nymph or larva; *c*, last stage of nymph; *d*, wingless female. Enlarged to 10 times natural size. (Chittenden)

THE COTTON APHID

The most abundant aphid on cotton plants is generally the cotton aphid (*Aphis gossypii* Glov.), also known as the cotton louse or melon louse. This cosmopolitan species feeds on a great variety of plants but is most injurious to melons, squashes, cucumbers, and other curcurbits, and to cotton and okra.

These aphids (fig. 8) vary greatly in coloration but are commonly green or greenish black, or yellow, with characteristic black markings.

In the South, full-grown females hibernate and in spring begin to reproduce. At this time, especially in cool weather, the aphids occasionally stunt, deform, or even kill seedling cotton.

They multiply at an extraordinary rate, except at extremely high temperatures. At times winged females appear and carry infestation to other plants. The aphids are commonly found on the lower sides of leaves (fig. 9); they may cause the leaves to curl and may retard the growth of plants. In a dry season plants sometimes shed their leaves as a result of aphid attack. After severe infestations the yield

of cotton may be reduced by 50 pounds of seed cotton per acre, on the average, with 100 pounds per acre as the maximum reduction.

The aphids are constantly sucking sap from the plants; and the excess fluid passed through their bodies drops on the leaves or on the ground as a clear sticky substance known as honeydew, which often becomes infected with a sooty fungus and turns black. Honeydew falling into open bolls may stain the lint and make it gummy, thus lowering its grade.

Planters are often unduly alarmed by the presence of aphids on their cotton, but they may be reassured by the fact that the plant

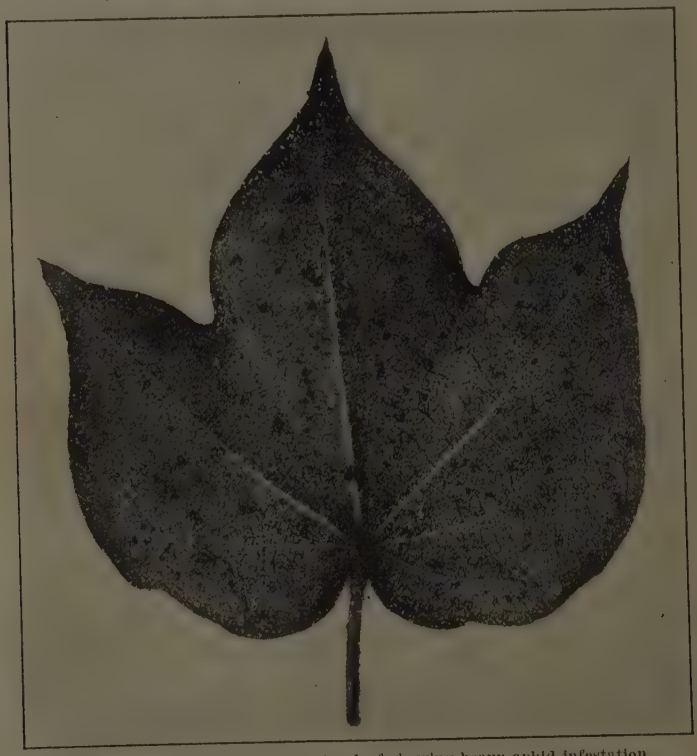

FIGURE 9.—Lower surface of cotton leaf showing heavy aphid infestation

usually resists aphid injury successfully. A single heavy rain may wash most of the aphids from the plants, and in damp weather a common fungus disease immensely reduces their numbers. A great many kinds of insect enemies act as checks on the multiplication of the aphids. Of these, the lady beetles are among the most important. Their presence on a plant indicates that aphids are there also. Ants visit cotton plants to get honeydew from the aphids.

Aphid infestation on cotton can easily be suppressed by applying, under proper conditions, a nicotine dust containing about 2½ per

cent of nicotine. Usually one application is sufficient. The dusting should be done only when the air is calm, and becomes more effective as the temperature rises. A single dusting may be made to serve for both boll weevil and aphid by mixing that percentage of nicotine with the calcium arsenate. In other cases hydrated lime is used as a carrier for the nicotine.

To make this nicotine dust, thoroughly mix 100 pounds of the carrier with 6¼ pounds or 5 pints of commercial nicotine sulphate solution which contains 40 per cent of nicotine. Apply the dust at the rate of from 6 to 9 pounds per acre.[5]

As nicotine dusts deteriorate rapidly upon exposure to the air, it is well to make them at home, just before they are to be applied.

THE PINK BOLLWORM

The pink bollworm (*Pectinophora gossypiella* Saund.) is a destructive pest of cotton and occurs throughout practically all cotton-producing regions of the world except in the United States, where it is found only in limited parts of Texas, New Mexico, and Arizona. However, on a few occasions this destructive pest has entered, and for short periods become established in, limited areas in the eastern part of the main Cotton Belt. These infestations have been wiped out by eradication campaigns carried on cooperatively by Federal and State agencies and usually involving the maintenance of cotton-free zones.

FIGURE 10.—The pink bollworm: Outline drawing of larva, showing structure. Enlarged to 6 times natural size. (Busck)

The occurrence of this dangerous pest in Mexico especially in the area along the Rio Grande, has resulted in its becoming established in the cotton-producing districts on or near the international boundary in the extreme western part of Texas and in certain valleys in New Mexico. Because of the menace that the pink bollworm presents to the cotton-producing areas in the United States, a strict quarantine is maintained on that limited portion of the three States in which it is known to occur. The quarantine regulates the movement of products likely to carry the pest and authorizes their movement from the regulated area only when they comply with safeguards necessary to prevent further distribution of the pink bollworm. In addition to governing the movement of products likely to carry the insect, Federal and State quarantine regulations provide for carrying on certain measures, such as the sterilization of cottonseed by heat, which reduce the abundance of the pest within the infested area. Another Federal quarantine regulates the entry into the United States of cotton and cotton products from countries in which the pink bollworm is known to occur.

The small whitish or pinkish caterpillars (fig. 10) eat out the seeds of the cotton plant, and not only diminish the yield of seed but also cause the seeds to be light in weight and low in vitality, with the oil content lessened and of low value. In addition, the lint is reduced in quantity and quality, being short, matted together, and

[5] U. S. Dept. Agr. Leaflet 53, Cotton-Louse Control.

more or less discolored. In cases of severe infestation both squares and small bolls are shed, as under boll weevil infestation. The pink bollworm, however, has a decided preference for bolls.

The adults are small brown moths (fig. 11) somewhat resembling the common clothes moths, active at night, quiet in the daytime, and easily overlooked even when abundant.

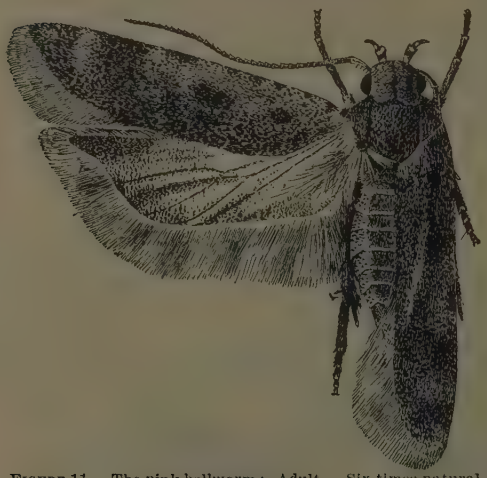

FIGURE 11.—The pink bollworm: Adult. Six times natural size. (Busck)

Several kinds of caterpillars superficially resemble the pink bollworm and may be mistaken for it. Positive identification of the insect in any of its stages can be made only by specialists and with the aid of a microscope. Agents of the Federal department as well as officers in the various States are continuously on the lookout for this pest. Should any reader of this bulletin find specimens which he thinks may be the pink bollworm, he should immediately kill them. A few specimens should be placed in formalin or some other preservative and forwarded to the Bureau of Entomology for identification. Under no conditions should live material be forwarded, distributed, or moved anywhere. To do so is a punishable offense under Federal and State laws.

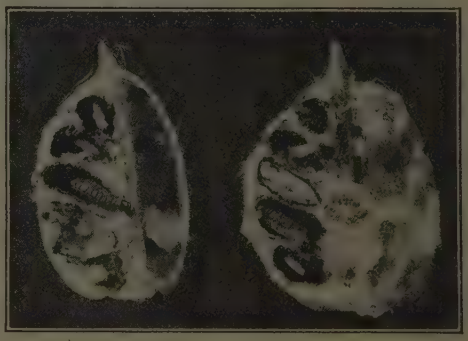

FIGURE 12.—Immature cotton boll showing characteristic damage by pink bollworm

An infestation may escape notice for a long time, as immature bolls containing the worms show no conspicuous external signs of their presence. (Fig. 12.) The larva when full grown cuts a round hole through the boll—a hole smaller than that made by the common bollworm. A clean-cut hole indicates that the larva has emerged to go to the ground to pupate (fig. 13); a hole with frass or castings in it is a sign that the larva is still

within the boll, where it often pupates. Occasionally a larva goes from one lock into the next one, and in so doing makes a characteristic round hole through the partition between the two locks. Often a larva hollows out two adjacent seeds and webs them together, forming the characteristic double seeds. (Fig. 14.) These double seeds pass through the gin, and their occurrence at a gin affords an easy means of detecting an infested locality.

FIGURE 13.—The pink bollworm: Pupa. Seven times natural size. (Busck)

The caterpillar, on hatching, bores into a square or boll. Infested squares usually form flowers, but these fail to open out fully on account of being webbed by the larva within. Since the insect requires only from one to two months in the growing season to develop from egg to adult, there may be three or more successive generations in one season, in the case of short-cycle larvae. Late in the season, however, other caterpillars, known as long-cycle larvae, may enter a resting condition, usually inside seeds, but sometimes in trash on the ground or on the taproots of cotton plants; this condition may last as long as 31 months (an extreme case) before pupation occurs. This longevity serves to carry the insect over unfavorable periods and also enables it to be transported alive to any part of the world.

In districts where the pink bollworm is known to occur, farmers should carefully abide by all regulatory orders issued by State or Federal Government. Such orders, particularly those

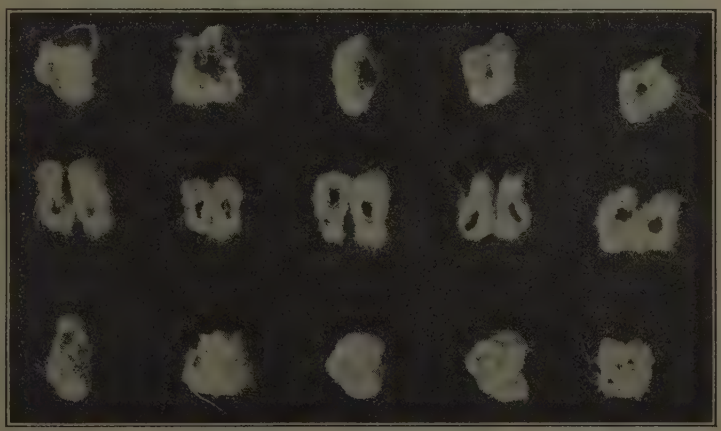

FIGURE 14.—Double seed formed by pink bollworm: Upper row, holes made for emergence of moth; middle row, seeds broken apart to show cavities; lower row, double seeds intact

which require the sterilization of seed, fumigation of lint, and disposal of gin trash, are promulgated to help reduce the numbers of this pest.

Farmers, in addition to carrying out these requirements, should try to secure as early a crop as possible. As soon as practical after the cotton is picked the old plants and all other crop remnants should be destroyed. Drying and burning is effective. The burial of old bolls, cotton stalks, and trash reduces the numbers of hibernating larvae. Early winter burial of crop remnants followed immediately by irrigation is very effective in destroying larvae within the soil and under certain soil conditions gives almost 100 per cent control.

THE COTTON LEAF PERFORATOR

The cotton leaf perforator (*Bucculatrix thurberiella* Busck), a leaf-mining insect, was discovered in Arizona on wild cotton (Thurberia). It occurs also in Texas and Mexico and has caused enormous losses to cultivated cotton in the Imperial Valley of California. Very high temperatures are favorable for its multiplication, but it can exist at altitudes of 4,000 or 5,000 feet, where the winters are comparatively cold, and, unless high humidity is an adverse influence, would apparently be able to survive under any climatic conditions that occur in the Cotton Belt.

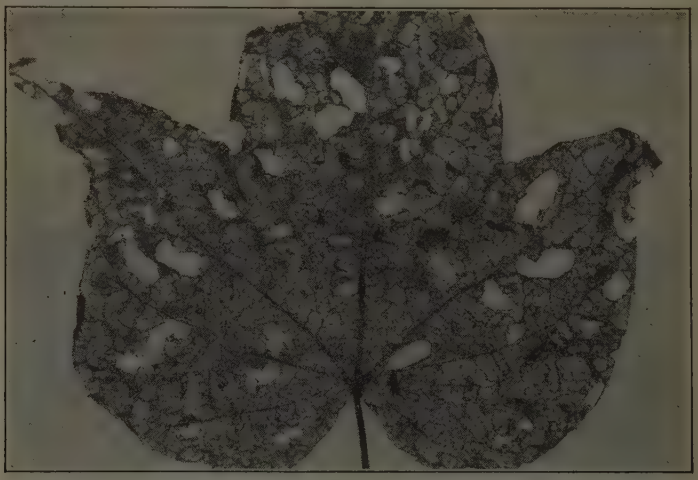

FIGURE 15.—Cotton leaf badly damaged by the cotton leaf perforator

Damage from the perforator is greatest on soils having low fertility, in poorly cultivated fields, and on volunteer cotton. The caterpillars destroy the foliage, causing the squares or small bolls to fall off, or the small bolls may open prematurely and produce a short-staple lint of little value.

At first the larva makes a serpentine tunnel, gradually widened as the larva grows. Older larvae make perforations in the leaves which often give the foliage a lacelike appearance. (Fig. 15.)

Characteristic of the greenish larvae are the black eye spots, prominent white tubercles, and particularly a pair of large, roundish black spots above, at the border of each body segment. The pale yellow egg, barely visible to the naked eye, is long, with longitudinal

ridges, and stands on end on a leaf. The white cocoon, spun on a leaf or elsewhere, is also longitudinally ribbed. The moths are small, white, and very active at night.

The period required for development from egg to adult ranges from about 15 to 70 days, according to the season. It averages 18 days, and there is a possibility of 9 or 10 generations annually in the Imperial Valley.

Preliminary tests have indicated that the perforator can be controlled profitably by dusting with powdered lead arsenate, used at the rate of 5 to 7 pounds per acre, and applied early in the morning when the air is calm and dew is on the plants. From one to three applications are necessary, according to the severity of the infestation.

THE RED SPIDER

The mite known as the red spider (*Tetranychus telarius* L.) has been, sporadically, one of the most destructive of cotton pests, especially in the Southeast. The first sign of mite attack is a blood-red spot on the upper surface of a leaf; then infested leaves turn red or rusty, dry up, and fall; bolls are shed and plants may die. This injury, often called "rust" by cotton planters, begins about the middle of June and may continue for about three months.

FIGURE 16.—The female red spider, 60 times natural size. (McGregor and McDonough)

The red spiders (fig. 16), barely visible to the naked eye, may be greenish or yellowish but are commonly red (female) or reddish yellow (male). These mites work on the undersides of leaves, laying their eggs there, spinning delicate webs, and sucking sap from the leaves, which become thickly dotted with their minute punctures. As many as 17 generations a year have been observed.

The red spider has been found on almost 200 species of plants, including garden and field crops, ornamentals, and weeds. In the South it survives the winter on such leaves as may remain green, as those of blackberry and various weeds. Pokeweed and the English violet have been sources of infestation on cotton. In early summer the mite may go from weeds into near-by cotton. When the cotton is no longer suitable as food the mites go back to the weeds. They have been seen crawling on the ground and are known to be carried by water and by wind.

Hot, dry conditions are most favorable for rapid multiplication of the red spider; heavy rains often check the pest effectively.

As a most important preventive, all weeds and underbrush near a cotton field should be cut and burned in winter or early spring. Growing weeds may be killed by spraying them with 1 pound of sodium arsenite in 20 gallons of water.

As red-spider injury to cotton is usually confined to young plants, early planting is advantageous. In an emergency an infestation that has not advanced far can be checked by pulling up and destroying such plants as show damage. Plowing affected areas to bury the

mites and save the rest of the field is advisable in cases of severe local infestation.

It is possible to kill the red spider by thoroughly spraying the undersides of the leaves with certain contact insecticides, such as potassium sulphide (1 ounce to 2 gallons of water), kerosene emulsion, or flour paste solution.[6]

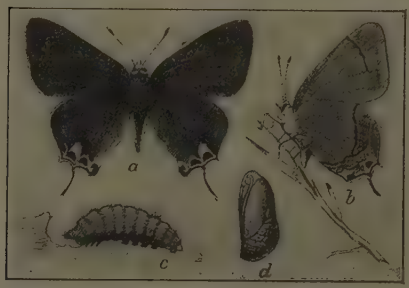

FIGURE 17.—Cotton square borer: *a*, Adult butterfly, top view; *b*, same from side, with wings closed; *c*, larva or borer, from side; *d*, pupa. Enlarged to 1⅛ times natural size. (Howard)

Dusting cotton with finely ground sulphur (sulphur flour) at the rate of 10 pounds per acre is recommended to control the red spider. As a combined boll-weevil and red-spider application, 8 pounds of sulphur may be mixed with 4 pounds of calcium arsenate for each acre.

MISCELLANEOUS INSECT PESTS OF COTTON

Most of the insects next to be considered are common in cotton fields and collectively do more or less damage. Occasional outbreaks of one or another, under special conditions, may call for special treatment; but ordinarily most of these miscellaneous insects are held in check incidentally by the measures used against the major insect pests. For example, the measures employed in control of the boll weevil operate also to suppress immense numbers of other insects on cotton.

FIGURE 18.—Yellow-striped army worm: *a*, Light form of larva; *b*, dark form of larva. Enlarged to 1⅛ natural size. (Chittenden)

THE COTTON SQUARE BORER

The cotton square borer (*Strymon melinus* Hbn.) is frequently found in cotton fields, where it attracts attention by boring into squares, but ordinarily it does not become of much economic importance, usually being held in check by its natural enemies. It is not limited to cotton but feeds also on okra, cowpea, bean, corn, goat-weed, and many other plants.

Like the bollworm, the square borer eats out the contents of squares, which then flare and are shed. It also bores in the growing tips of the cotton plant. Unlike the bollworm, however, this borer is a little, oval, velvety-green caterpillar (fig. 17), which at length becomes a small bluish-gray butterfly.

This borer can be controlled when necessary by dusting the cotton with calcium arsenate at the rate of from 5 to 7 pounds to the acre. The regular dustings for the boll weevil incidentally check this and several other cotton insects.

[6] Farmers' Bulletin 831, The Red Spider on Cotton and How to Control It.

THE YELLOW-STRIPED ARMY WORM

The yellow-striped army worm, or cotton-boll cutworm (*Prodenia ornithogalli* Guen.) feeds on various kinds of weeds, field crops, truck crops, and ornamental plants. It is common on the foliage of young cotton plants, and may dwarf or deform the growth of the plants, retard fruiting, or even kill them. It bores into bolls as does the bollworm, but its worst injury is to young cotton, which it attacks after the manner of other cutworms (p. 24), causing loss of stand.

The caterpillar (fig. 18) is olive green or greenish brown in color, with rows of triangular black spots on the back. The adult or moth is shown in Figure 19.

Frequent cultivations destroy the pupae in the soil. Dusting with calcium arsenate for the boll weevil also kills these and other caterpillars. On young cotton the methods of control used for other cutworms (p. 24) are effective.

FIGURE 19.—Yellow-striped army worm: Above, dark form of moth, male; below, pale form of moth, female. Enlarged to 1⅛ times natural size. (Chittenden)

THE COTTON STAINER

In the United States a West Indian species, the cotton stainer, or red bug (*Dysdercus suturellus* H.-Sch.) has been injurious only in Florida, where it was at one time the most important cotton insect. It has been reported also from Georgia, South Carolina, and Alabama.

FIGURE 20.—Cotton stainer: *a*, Fourth-stage nymph; *b*, adult. Enlarged to 4 times natural size. (Insect Life)

These conspicuous red and brown or red and black bugs (fig. 20), occurring in colonies, puncture bolls and seeds, often destroying small bolls and ruining parts of large ones. The sap from young bolls or from seeds sucked by the insects, with excremental fluid as well, stains the lint brownish yellow or reddish and greatly lowers its value.

These bugs feed also on a few wild plants, such as nightshade and particularly Spanish cocklebur. Weeds upon which the bug breeds should be destroyed.

The fact that the cotton stainers occur in colonies, limited for a long time to one or a few plants, permits their destruction by hand. They can be jarred into a bucket of water having a surface layer of kerosene. In fall and early spring small piles of cottonseed attract great numbers of these bugs, which may then be killed with hot water or kerosene.

FIGURE 21.—Cotton boll showing punctures of cotton plant bug. (Sanderson)

THE COTTON PLANT BUG

The cotton plant bug (*Adelphocoris rapidus* Say) feeds on many kinds of cultivated plants and on weeds. On cotton it punctures not only leaves and stems but also squares and young bolls, which fall off as a result. On larger bolls (fig. 21) each puncture becomes surrounded with black, giving the appearance of pink boll rot or anthracnose. The greatest damage by the bug on cotton is due to its puncturing very small squares, which then become blasted and are shed. In causing blasted squares and consequent lack of blooms, this bug produces injury similar to that of the cotton flea hopper.

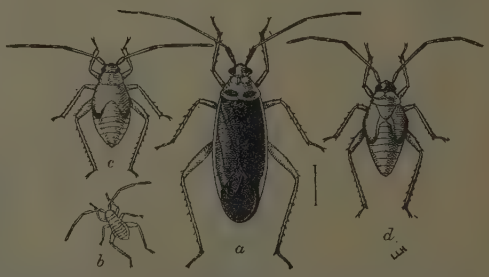

FIGURE 22.—Cotton plant bug: *a*, Mature bug; *b*, young nymph; *c*, fourth-stage nymph; *d*, fifth-stage nymph. Enlarged to 4 times natural size. (Sanderson)

The adult bug (fig. 22) is dark brown above, edged on each side with yellow. The nymphs are pale green, marked with red.

Dusting the cotton plants with sulphur, as for the flea hopper (p. 9), is recommended as a means of control.

THE TARNISHED PLANT BUG

A widely distributed and omnivorous pest of plants is the tarnished plant bug (*Lygus pratensis* L.), which not only feeds on a great many kinds of weeds but also attacks fruit trees, small fruits, truck crops, flowering plants, and some grains.

The adult (fig. 23) is yellowish brown to blackish in general color, variegated with shades of yellow, red, and black. The nymphs or young bugs are green, and the older nymphs have four black spots on the thorax.

The bugs hibernate as adults under dead leaves, rubbish, loose bark, or other shelter, from which they emerge early in spring. Eggs are laid on a great variety of plants, and may be inserted into stems or leaves, or laid in flower heads, especially those of composites, among which certain species of fleabane (*Erigeron* sp.) are preferred. Weeds, in fact, are the natural breeding plants of this insect.

In 1926 this species was very abundant in the Southern States, where it made destructive and unprecedented attacks on cotton. It was associated with the cotton flea hopper in blasting young squares, thereby preventing the formation of flowers, and causing an abnormal growth and development of the plant. The bugs attacked the cotton in the day time. Millions of them spent the nights in the dense weeds around the borders of the cotton fields. At sunrise they left the weeds and flew back to the cotton.

FIGURE 23.—The tarnished plant bug: Adult bug at left; last stage of nymph at right. Nearly 4 times natural size. (Orton and Chittenden)

Dusting cotton plants with sulphur, as for the flea hopper (p. 9), is recommended. Weeds and other trash should be burned in cold weather to destroy hibernating bugs. Cutting and burning the weeds during the growing season will kill many of the wingless nymphs.

THE COTTON DAUBER

The cotton dauber (*Lygus elisus* Van D.), which closely resembles the tarnished plant bug, has been a pest in Arizona and New Mexico and one of major importance in California, particularly in the Imperial Valley.[7] There it occurs on alfalfa during most of the growing season. When the alfalfa dries out or is cut in early summer, however, the insect migrates into near-by cotton. On alfalfa the pest distributes its damage, but on cotton it concentrates entirely on buds, blooms, and young bolls, which are soon shed in consequence. As the bug sucks sap from the plant it deposits drops or daubs of yellow excrement—hence its name.

In combating this bug on either alfalfa or cotton, a single application of sulphur dust, at the rate of 10 pounds per acre, as for the flea hopper (p. 9) has been found to be effective.

THE GARDEN WEBWORM

The garden webworm (*Loxostege similalis* Guen.), common throughout North America, attacks a great variety of garden and field crops, and has at times ruined fields of small corn and cotton, necessitating replanting.

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[7] U. S. Dept. Agr. Tech. Bul. 4, Lygus elisus: A Pest of the Cotton Regions in Arizona and California. 1927.

The caterpillar feeds primarily on weeds, preferring pigweed (Amaranthus), known also as "careless weed," and is often called the "careless worm." The moths emerge from the soil in spring and may lay eggs on cultivated plants if its preferred weeds are not at hand. Larvae may feed on alfalfa in early spring until the crop is cut and then move into adjoining corn or cotton.

The larvae (fig. 24), which are yellowish or greenish yellow with conspicuous black dots make webs on the foliage of plants and pupate in the soil. The moths (fig. 25) vary in color, being commonly grayish but often reddish yellow.

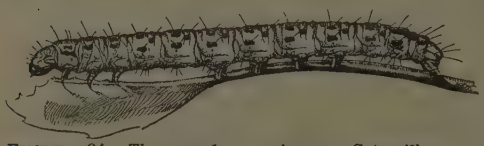

FIGURE 24.—The garden webworm: Caterpillar or "worm." Three times natural size. (Kelly and Wilson)

The destruction of weeds is advised as a preventive. Thorough cultivation of land in fall or winter is recommended. Dusting with calcium arsenate is effective as a check.

THE SALT-MARSH CATERPILLAR

The salt-marsh caterpillar (*Estigmene acraea* Dru.), common everywhere on grasses, weeds, garden crops, and so forth, has on rare occasions been sufficiently abundant to strip entire fields of cotton. It may dwarf or deform seedling plants, retard fruiting, or kill the plants.

FIGURE 25.—Parent of the garden webworm. Four times natural size. (Kelly and Wilson)

The caterpillar, one of the "woolly bears" (fig. 26), is clothed with long, brown or black hairs arising in clusters from yellow tubercules.

Control of weeds around cotton fields is a logical method of checking this and many other cotton insects. Direct methods of control by means of poisons are the same as for the cotton leaf worm (p. 7).

THE FALL ARMY WORM

The fall army worm, or grass worm (*Laphygma frugiperda* S. and A.), a native of subtropical America, is common every year in the United States, and at times, under favorable conditions, becomes abundant and destructive. In this country the insect is able to survive the winter only in southern Florida and southern Texas, but as the season advances successive broods may spread over the United States east of the Rocky Mountains and even into Canada.

The worms normally feed on grasses of many kinds, especially crab grass and Bermuda grass, and if they are not full grown after consuming these they travel in search of more food. They are very destructive to cultivated grasses, especially corn and sorghum, and to alfalfa and cowpeas, but will attack almost any field or truck crop. Cotton is not a favorite food plant of the fall army worm, but a poorly cultivated cotton field, overrun with grass, may be injured. On cotton the worm characteristically tops the plants, cutting off branches and squares. Severe damage to cotton, to the extent of defoliation, occurs rarely and only under exceptional conditions, as, for example, when other food is scarce, as after an overflow.

FIGURE 26.—Salt-marsh caterpillar: *a*, Male moth; *b*, half-grown larva or caterpillar; *c*, full-grown larva, side view; *d*, head of larva, front view; *e*, egg mass. All enlarged to 1¼ times natural size except *d*, which is more enlarged. (Chittenden)

The worms (fig. 27) attain a length of 1½ inches, and vary in general coloration from pale green to almost black. Usually the front of the head has a white mark like an inverted Y which is characteristic of the species. The adult is a dull-grayish moth having satiny-white hind wings.

Proper cultivation usually will protect a cotton field from this worm. Shallow cultivation after the worms have entered the soil to pupate destroys many pupae and exposes others to the killing heat of the sun. Fall plowing is a useful preventive.

While young worms are still feeding in grasslands they can be killed by dusting with calcium arsenate or other arsenicals. Spraying with 1 pound of powdered lead arsenate to 50 gallons of water is also a means of control. Poisoned bran mash, as used for cutworms (p. 24), is an effective bait for this caterpillar also.

Fields which have been sprayed or dusted are dangerous as pastures until after a heavy rain has fallen or for at least three weeks after the insecticide has been applied.

A field can be protected from an advancing army of these worms by making a barrier in the form of either a deep furrow or a line of coal tar.[8]

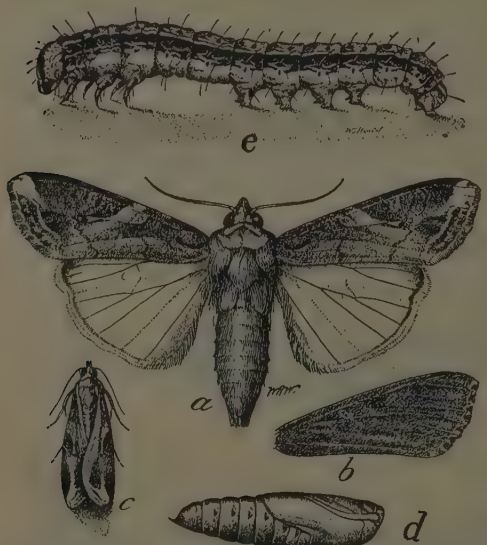

FIGURE 27.—Fall army worm or grass worm: *a*, Adult male moth; *b*, right front wing of female moth; *c*, moth in resting position; *d*, pupa; *e*, full-grown larva. *a*, *b*, *d*, *e*, About twice natural size; *c*, slightly enlarged. (Walton and Luginbill)

THE COWPEA CURCULIO

A bronze-black weevil, the cowpea curculio (fig. 28) (*Chalcodermus aeneus* Boh.), has often been locally destructive to cotton in the Gulf States, Georgia, South Carolina, and North Carolina. Its damage is done in the early spring to small cotton, which the weevils may eat down to the ground, but this injury has occurred only in fields that were in cowpeas during the preceding year. The beetles hibernate in the

FIGURE 28.—Cowpea curculio: *a*, Adult weevil; *b*, larva, side view; *c*, head of same, front view; *d*, pupa, viewed from below. Five times natural size, except *c*, which is enlarged about 12 times. (Chittenden)

soil of the cowpea field and after emerging attack young cotton in the absence of other food.

[8] Farmers' Bulletin 752, The Fall Army Worm, or "Grass Worm," and Its Control.

It has been suggested that cotton following cowpeas be planted thickly and the chopping delayed as long as possible in order to secure a uniform stand.

MAY BEETLES

A few species of May beetles (*Phyllophaga cribrosa* Lec., *P. lanceolata* Say, *P. farcta* Lec.), two of which are shown in Figures 29 and 30, have occasionally injured seedling cotton plants considerably, especially in Texas and Oklahoma. These species winter in the soil as white grubs or as beetles and their damage consists of the destruction of young plants by the beetles. These feed by night or in the darker part of the day on various cultivated plants or on weeds, and hide in the ground during most of the daytime. The damage is greatest in fields of cotton following grass or weeds. Weeds and cotton fields may be dusted with calcium arsenate if necessary at the rate of from 4 to 6 pounds per acre. Winter plowing has been recommended to kill the grubs and beetles in the soil.

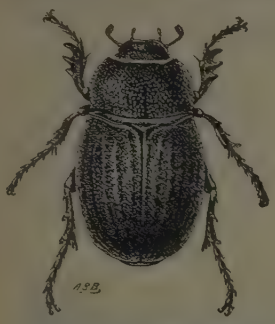

FIGURE 29.—May beetle, *Phyllophaga cribrosa*. Enlarged to 1½ times natural size. (Sanderson)

FIGURE 30.—May beetle, *Phyllophaga lanceolata*. Enlarged to 1½ times natural size. (Sanderson)

GRASSHOPPERS

Grasshoppers have in some years been very destructive to cotton in some of the Southern States, especially Texas. Two species have been especially injurious. The differential grasshopper (*Melanoplus differentialis* Thos.) has destroyed hundreds of acres of cotton at a time in Mississippi and Texas. Its eggs, laid in uncultivated ground, hatch in early spring, and the grasshoppers feed at first on grasses and weeds, but if this food fails they may attack young corn or cotton. The lubber grasshopper (*Brachystola magna* Gir.) (fig. 31), a clumsy, short-winged species, often injurious in Texas, unfortunately attacks cotton during the entire season.

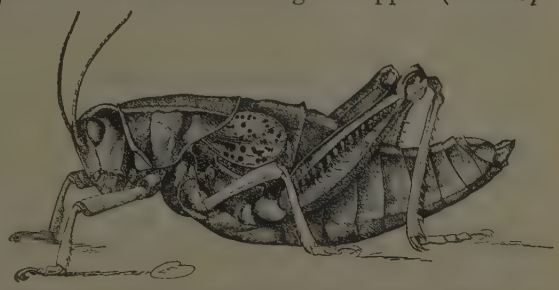

FIGURE 31.—Lubber grasshopper: Adult female, natural size. (Walton)

It has been found possible to check these grasshoppers by spraying weeds and grasses on uncultivated lands with kerosene or crude oil. Dusting with calcium arsenate or other arsenical is recommended. Poisoned-bran mash, as used for cutworms, has proved an effective means of control, but when it is used cooperation among planters is essential to the best results.

CUTWORMS

Young cotton plants are often destroyed by several species of cutworms, which cut the stem in two or feed on the leaves.

The cutworms (fig. 32), of which there are many kinds, are stout, cylindrical, almost naked caterpillars, gray to brown or blackish in color, sometimes spotted or striped, commonly found in the soil and usually curled up when resting. During the day they are usually hidden in the soil or under clods or other shelter, but by night or on dull days they feed by cutting the stems of onion, cabbage, potato, corn, and other small plants. Often a cutworm burrows into the soil close by a plant that it has cut, and so may easily be found.

FIGURE 32.—A cutworm, *Agrotis ypsilon:* *a*, Larva; *b*, head of same; *c*, adult moth. Natural size, except *b*. (Riley and Howard)

Cutworm damage to cotton in spring has frequently been so severe as to necessitate replanting. A heavy sowing of seed to secure a good stand of cotton is an insurance against serious damage.

The recommended remedy for cutworms, and various other chewing insects as well, is poisoned-bran mash, which is prepared as follows:

Wheat bran	25 pounds
Paris green or white arsenic	1 pound
(Or else calcium arsenate or lead arsenate, 2 pounds)	
Low-grade molasses or blackstrap	2 quarts
Water	3 to 5 gallons

Mix the bran and poison thoroughly. Add the molasses and mix again, then add water. The resulting mixture should be crumbly, so that it can be broadcast. At least 10 pounds per acre should be scattered over a field, preferably in the evening, as the mash is more effective when moist. Keep poultry and livestock out of poisoned fields.[9]

SHARPSHOOTERS

Several kinds of sharpshooters (*Homalodisca triquetra* Fab., *Oncometopia undata* Fab., *O. lateralis* Fab., and *Aulacizes irrorata*

[9] Farmers' Bulletin 739, Cutworms and Their Control in Corn and Other Cereal Crops.

Fab.) (fig. 33) are familiar insects in cotton fields in summer and fall, and when approached attract attention by their habit of dodging around the stem of a plant.

These insects should be mentioned because they are so often blamed for damage to the cotton plant. They are not known to attack squares, blooms, or bolls, however, although they habitually puncture the stem and from it they extract, in the aggregate, immense quantities of sap. This constitutes a drain on the plant which theoretically would tend to retard growth, but as a matter of fact the plant seems able to withstand this loss of sap, and injury from these insects is probably slight.

The sharpshooters, generally speaking, hibernate as adults, feed in spring on elm, willow, cottonwood, hackberry, etc., and later on other plants, such as sunflower, sorghum, corn, and cotton, and are always common on weeds. The eggs are sometimes laid on cotton, but usually on other plants.

FIGURE 33.—A sharpshooter, *Homalodisca triquetra:* Adult at left; last-stage nymph, or young, at right above; young nymph at right below. Enlarged to 4½ times natural size. (Sanderson)

THE CORN ROOT APHID

The bluish-green plant louse called the corn root aphid (*Anuraphis maidiradicis* Forbes) is a pest of corn in the North and has at times been destructive to young cotton in the South, especially in North Carolina and South Carolina.

Young, tender plants, as soon as they are out of the ground, may turn red and die when these lice are sucking sap from the roots. When the roots get hard and woody the winged aphids leave them, and the wingless aphids are transferred by their attendant ant companions to succulent roots of other plants. The most serious injury to cotton has occurred where it was planted after corn.

The simplest method of control is a system of rotation in which cotton does not directly follow corn or cotton. A 3-year rotation that has proved successful is (1) oats and cowpeas, (2) cotton, (3) corn. The borders of fields should be kept free from weeds, many of which harbor the aphids. A shallow cultivation of infested fields breaks up the nests of the ants that care for these aphids, and kills many of the aphids by burying them.

WIREWORMS

At least two species of wireworms (*Monocrepidius vespertinus* Fab. and *Horistonotus uhleri* Horn) have done considerable damage to young cotton, particularly in South Carolina. The worms are especially troublesome because of the fact that they may live in the

soil for two and possibly three years before transforming into beetles. These wireworms bore into seeds or eat the roots of young plants, often killing the plants before they have appeared above ground. Affected plants, if not killed, are dwarfed and sickly. Commonly the injury occurs in spots in fields; often there are bare spots where all the young cotton has been killed.

The adults are the well known click beetles (fig. 34), so called because when one of them happens to be on its back it bends upward and then, by suddenly straightening out, snaps itself into the air with a click. This process is repeated, if necessary, until the beetle lands on its feet. These beetles feed more or less on foliage of cotton and are said to injure young squares also.

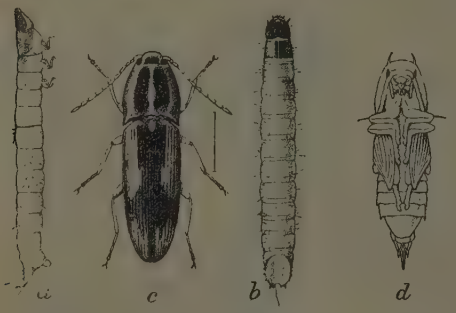

FIGURE 34.—A cotton wireworm, *Monocrepidius vespertinus*: *a*, Larva, or wireworm, side view; *b*, same, top view; *c*, adult, or beetle; *d*, pupa. Three and one-half times natural size. (Chittenden)

No entirely satisfactory method for the control of these wireworms has yet been developed. However, since the sandy-land wireworm (*Horistonotus uhleri* Horn) does not lay its eggs on untilled soil, a system of handling the ground and the crops preceding cotton so that the soil will not be disturbed from the middle of June to the middle of August is very important. This may be accomplished by omitting from the rotation such crops as require summer cultivation.

GENERAL CONSIDERATIONS

To get a good crop of cotton in spite of the insect pests, the greatest possible amount of cotton must be matured in the shortest possible time. The rate of fruiting must outstrip the rate of insect multiplication. This involves the agricultural practices given in this bulletin. Of these, the importance of seeding heavily must be emphasized. An excess of seedlings may not only give a good start toward a good stand of plants, but may also insure a good stand even when insect enemies of young plants (as cutworms, webworms and other caterpillars, May beetles, grasshoppers, root aphids, and wireworms) are present.

As has been stated, comparatively few cotton insects are habitually of sufficient importance to require direct control measures. Many others are less important but nevertheless of importance in the aggregate, and some of them may, under special conditions, demand special methods of control. As a rule, however, the methods used to control the major insect enemies of the cotton plant will control or restrain many of the minor ones at the same time.

The insects that the cotton planter has to deal with fall into two groups according to the nature of their mouth parts and consequent habit of feeding—the chewing and the sucking insects. Correspond-

ingly, there are two classes of insecticides, broadly speaking—stomach poisons and contact insecticides. Chewing insects (weevils, beetles, caterpillars, grasshoppers) can be killed by means of a poison such as calcium arsenate applied to their food. Calcium arsenate is at present the poison best adapted to the needs of the cotton grower. A sucking insect, on the contrary, which pierces a plant with its beak and sucks the sap (flea hopper, leaf bug, other plant bugs, and plant lice) can not be controlled with a stomach poison, but succumbs to contact insecticides, of which two are commonly used in cotton fields, nicotine dust and finely ground sulphur (sulphur flour).

In cases of joint infestation, as when, for example, both boll weevils and plant lice are attacking plants at the same time, a combined application (in this instance nicotine dust with calcium arsenate as the carrier) frequently can be made.

SUMMARY OF CONTROL MEASURES

While special methods are necessary to control outbreaks of several of the cotton insects, the measures used to control the boll weevil operate also against most of the other insect pests of cotton.

It is most important to plant a variety of cotton that is adapted to weevil conditions; in other words, that will produce the greatest possible quantity of fruit in the shortest possible time.

Sow the seed heavily, to insure a good stand of young plants to begin with.

Practice reasonably early planting and frequent careful cultivation.

Use fertilizers where required.

Pick the cotton as soon as possible and then destroy the plants without delay, by grazing, burning, or plowing them under. When conditions permit, cotton stalks should be turned under instead of being burned. The stalks should be destroyed at least two weeks before the first killing frost is likely to come, if much benefit is to be had from that measure; and one month before, in order to get the maximum benefit. This method is obviously most suitable for the more southerly parts of the Cotton Belt, where the crop matures early and the first killing frost comes late.

Burn weeds and other trash in winter. Burn especially the weeds on ditch banks, at the edges of timber adjoining cotton fields, and within the cotton field.

Keep down weed growth near cotton fields in spring.

Rotate crops, following a system of rotation that is best adapted to prevent insect infestation and maintain soil fertility in your particular locality.

Watch the progress of boll weevil infestation and control the weevil by dusting with calcium arsenate at the proper times and in the correct manner.

Always have a supply of calcium arsenate on hand for emergency use as well as for regular boll weevil dusting.

If you desire information concerning an insect that is strange to you, send specimens of the insect, properly preserved, to the Bureau of Entomology of the United States Department of Agriculture, Washington, D. C.

Additional printed matter on the more important kinds of cotton insects may be obtained from the Division of Publications of the United States Department of Agriculture, Washington, D. C.

It will pay the planter to learn to distinguish the injurious cotton insects, to recognize the work of each one of them on the plant, and to inspect his fields frequently, that he may detect insect damage when it begins and may be able to remedy it promptly.

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